Lesson - 04

Breathing And Exchange of Gases

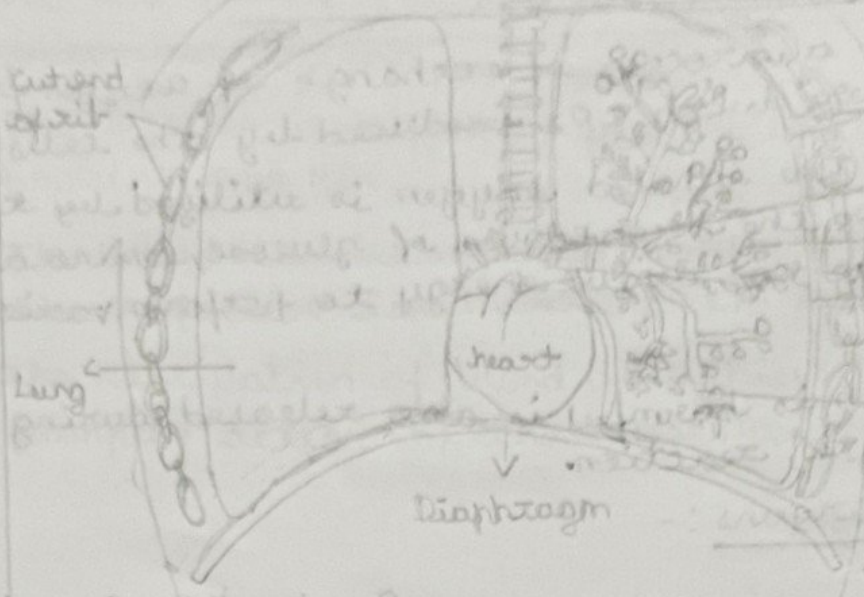
- Breathing is a process of exchange of oxygen from the atmosphere with CO_2 produced by the cells.
- Respiration :- The inhaled oxygen is utilized by the organism for the breakdown of glucose, amino acids, fatty acids to derive energy to perform various activities.
- The CO_2 which is harmful is also released during above catalytic reaction.

Respiratory Organs :-

Examples	Respiratory organs
• Sponges, coelenterata, ctenophora, flatworm.	• Body surface (simple diffussion)
• Annelida, Frog (Amphibia)	• moist skin (cutanious respiration)
• Arthropoda (Insects)	• Trachea (Tracheal respiration)
• Scopian (Arthropoda)	• Book lungs
• Limulus (King crab)	• Book gills
• Aquatic (Arthropoda) Amphibia and fishes	• Gills (Bronchiole respiration)
• Some amphibians Reptiles/ Aves / mammals	• Lungs (Pulmonary)

Human Respiratory System :-

- Study of respiration is called rhinolaryngology (E N T)
- It begins with the pair of nostrils (External nares)
- Nostril give rise to nasal passage, divided into right & left by nasal septum.
- Nasal chamber is divided into 3 parts :-
  - i Vestibular chamber (Hair & mucus cell help in filtration)
  - ii Respiratory region (It warms and moisten the air)
  - iii Olfactory region (It has the receptor of smell)
- Nasal chamber opens into pharynx. Pharynx is common passage for food and air.
- Pharynx is short tube like structure.



Lungs

- ~~Eac~~ Pharynx gives rise to cartilagenous box like structure called larynx which helps in production of sound.
- In birds larynx is called syrinx
- opening of trachea is called glottis which is covered by thin elastic cartilagenous flap like structucture which is epiglottes.
- Epiglottes close the glottes when and prevents entry of food to larynx and trachea.
- The trachea is straight tube extendeding upto midthoracic cavity which divides at the level of 5th thorasic vertebrate in left and right bronchi
- The initial bronchi's are called primary bronchi which undergo repeated divisions to form secondary and tertiary bronchi.
- Tertiary bronchi further give rise to the bronchioles called initial, terminal and respiratory bronchioles.
- Trachea
  ↓
  P bronchi
  ↓
  S bronchi
  ↓
  T bronchi
  ↓
  Bronchioles
  ↓
  Terminal bronchioles
  ↓
  Res bronchioles

- From trachea to initial bronchioles it is covered by C shaped elastic cartilagenous ring (Hyaline cartilagenous ring / incomplete cartelagenous ring). which is 16 - 20 in number.
- It prevents trachea from collapsing (which generally occurs while swallowing).
- Each terminal bronchiole give rise to number of very thin irregular walled and vascularised bag like structure called alveoli.

Note:-

Terminal bronchioles
↓
Respiratory bronchioles
↓
Alveolar duct
↓
Atria
↓
Alveoli

- The branching network of bronchi, bronchioles and alveoli comprises the lungs.
- Alveoli is the functional unit of lungs, there a 300 millions of alveoli per lungs.
- From trachea to alveoli there ~~are~~ 2 zones is called conducting zone / dead space region
- From Respiratory bronchioles to Atria it is called respiratory zones.
- The air present in dead space region is called dead space air.
- The part starting with external nostril upto terminal bronchiole constitute the conducting part which transports the atmospheric air to alveoli and it also clears the air from foreign particles, humidifies and brings the air to the body temperature
- The alveoli and their duct forms the respiratory zones / exchange part ~~which~~ is where the actual diffusion of O_2 and CO_2 between the blood and atmospheric air takes place.

Lungs :-

- We have 2 lungs which is covered by a double walled membrane called pleural membrane.
- The outer pleural membrane (Parietal pleura) is in close contact with thoracic lining where (Visceral pleura) is in close contact with lung surface.
- The space between the pleural membrane is called pleural space which is filled by a fluid called pleural fluid.
- The pleural fluid reduces the friction on lung surface and keeps lungs moist.
- The lungs are situated in the thoracic ~~box~~ chamber which is anatomical air tight chamber which is formed dorsally by vertebral coloumn ventrally by sternum laterally by ribs and on the lower side by the dome shape diaphragm (It is made up of skeletal muscle which is also known as Phrenic muscle).
- The volume of thoracic cavity is called thoracic volume and the volume of lungs is called pulmonary volume.
- The change in the volume of thoracic cavity will lead in the change of volume in pulmonary cavity.
- It is very much essential for breathing as we cannot directly alter the pulmonary volume.

Note :-

- The right lung is larger than left lung as the left lung has a ~~diff~~ diffresion called cardiac nodge.
- The right lung is divided into 3 lobes :- superior, middle and Inferior
- Left lung is divided into seperior and inferior
- The right lung is moved slightly upward and looks shorter due to presence of liver.

Steps of Respiration :-

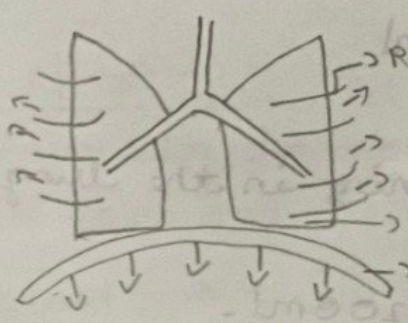
- Breathing or Pulmonary ventilation by which atmospluscasr is drawn in the CO_2 rich alveola air is released out.

- Diffusion of gases (O_2 and CO_2) across alveolar membrane.
- Transport of gases by the blood
- Diffusion of O_2 and CO_2 btw blood and tissue.
- Utilisation of O_2 by the cells for catabolic reaches and resultant release of CO_2 (cellular respiration as does in the chapter).

Mechanism of Respiration :-

- It involves 2 stages, inspiration & expiration.
- Inspiration is a process during which atmospheric air is drawn in.
- Expiration is a process by which alveolar air is released out.
- Principal :-
- The movement of air into and out of the lungs is carried out by creating a pressure gradient btw lungs and atmosphere.
- The diaphram and intercoastal muscles (external & internal) help in generating the pressure gradient required for inspiration and expiration.

	Inspiration	Expiration
Pressure Gradient	-ve pressure inside the lungs	Pressure inside the lungs is more than atmosphere
Diaphragm	contracts (flat)	Relax (dome shaped)
Intercoastal muscle	External IM lifts the ribs and sternum	Internal IM pull the ribs & sternum
Thoracic volume	Increases	Decreases
Pulmonary Volume	Increase	Decreases
Intrapulmonary pressure	Decreases	Increases
Atmospheric pressure	More than IPP, Air moves from atmosphere to lungs	Less than IPP hence air moves from lungs to atmosphere



Expiration

- Inspiration takes 2s and expiration takes 3s.
- Spirometer is a instrument which is used to know the volume of air in breathing movement.
- We have the ability to increase the strength of inspiration or expiration with help of abdominal muscle.
- A healthy human can breath 12-16 times per minute.

Note:-
Spirometer helps in clinical assesment of pulmonary function (diagnosis of two disorder of lungs).

Respiratory Volumes and Capacities.

i **Tidal volume**
- The volume of intake air inspired and expired during normal breathing
- Tidal volume per breathing is 500ml and per minute is 6000-8000ml.

ii **Inspiratory reserve volume**
- Additional volume of air inspired by forcible inspiration.
- This averages 2500ml - 3000ml

iii **Expiratory Reserve Volume**
- Additional volume of air a person can expire by a forcible expiration.
- It averages 1000 - 1100ml

iv **Residual Volume**
- Volume of air remaining in the lungs even after forcible expiration
- This averages 1100 - 1200ml.

i Inspiratory capacity

- The total volume of air a person can inspire after normal expiration.
- It includes tidal volume + Inspiratory reserve volume
- It ranges from 3000 ml - 3500 ml.

ii Expiratory capacity

- The total volume of air a person can expire after normal inspiration.
- It include tidal volume + Expiratory reserve volume
- It ranges from 1500 - 1600 ml

iii Functional Residual volume

- The volume of air remain in lungs after normal expiration.
- It includes tidal volume + Residual volume + ~~ERV~~
- It ranges from 1200 - 1300 ml

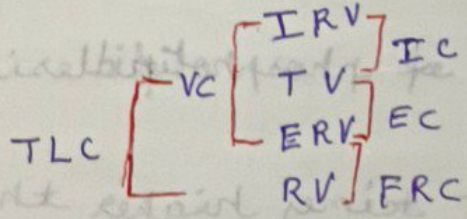
iv Vital Capacity

- The maximum volume of air a person can inspire after a forced expiration.
- This includes ERV + TV + IRV
- It ranges from 4200 - 4700 ml

v Total lung Capacity

- Total volume of air remains in the lungs at the end of forced Inspiration.
- It includes RV + ERV + TV + IRV or VC + RV
- It ranges 6000 ml.

Note :-



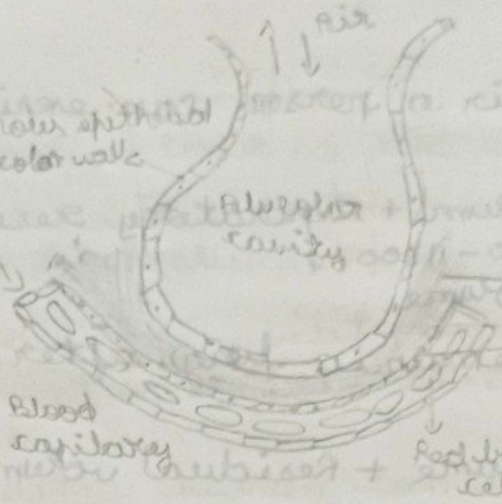
Exchange of Gases :-

- Alveoli is major site for exchange of gases
- Exchange of gases takes place between

Blood $\rightleftharpoons$ tissue By simple diffusion

- Diffusion of gases depends on:-

1. Thickness of diffusion membrane (less than millimeter)
2. Solubility of gases
3. pressure / concentration gradient of O_2/CO_2 (partial pressure of gases).



- Diffusion membrane is found found by alveolar epithelial, basement membrane & endothelium of blood capillaries.
- The thickness of these membrane should be less than one milimeter which helps in easy exchange of gases.

To know:

- The alveolar epithilium is made up of 2 types of cells.

  Type I -> squamous epithilium (pneumocytes which helps in diffusion of gases)

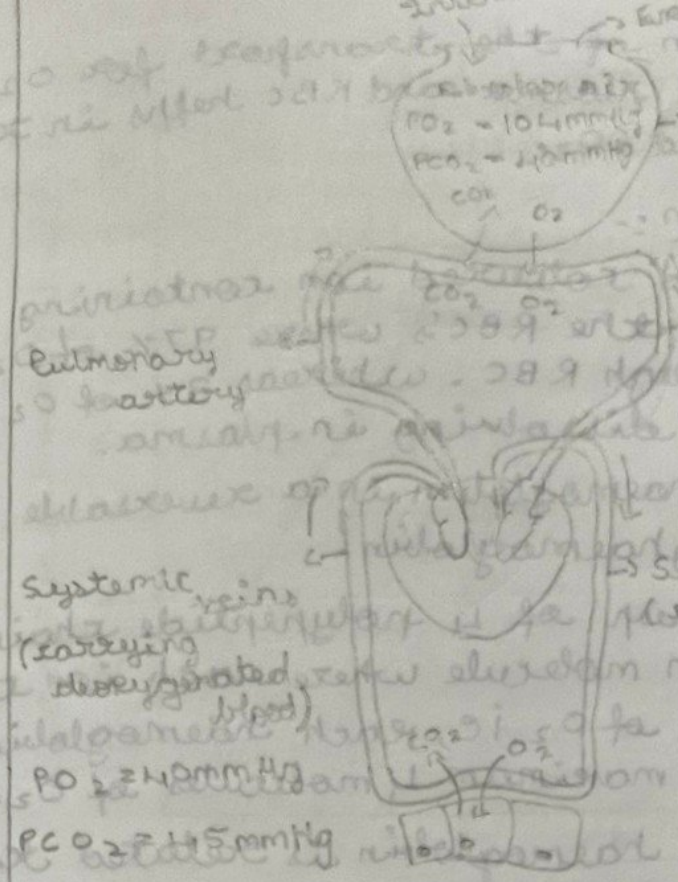
  Type II -> cuboidal epithilial (which in synthesis of circumtance which prevents alveoli from collapsing)

- circumtance are made up of phospholipid lecithin

Solubility of Gases.

- Solubility of CO_2 is 20 to 25 times higher than oxygen hence it can diffuse at faster rate through diffusion membrane as compared to oxygen.

Partial pressure of gases


Alveolus
Pulmonary artery
Pulmonary vein
Systemic veins
(carrying deoxygenated blood)
Systemic arteries
(carrying oxygenated blood)
PO2 = 40mmHg
PCO2 = 45mmHg
PO2 = 95mmHg
PCO2 = 40mmHg

Body Tissue

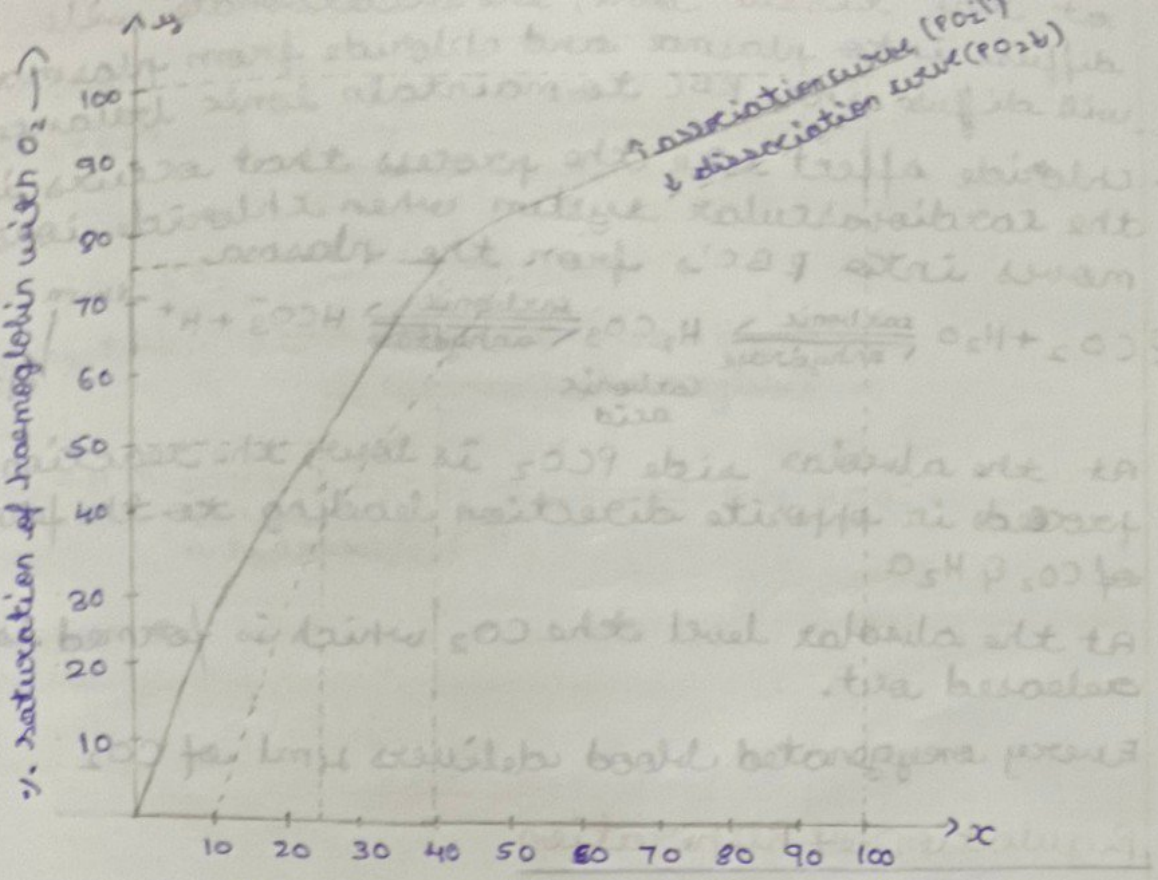
- Blood ... and CO_2. The blood ... transport of O_2 and CO_2.

Transport of oxygen :-

- Haemoglobin is a red coloured iron containing pigment present in the RBC's where 97% of O_2 is transport through RBC. whereas 3% of O_2 is transported by dissolving in plasma.
- O_2 can bind with haemoglobin in a reversible manner to form oxyhaemoglobin.
- Haemoglobin is made up of 4 polypeptide chain each chain with iron molecule where each iron can carry one molecules of O_2 ie, each haemoglobin molecules can carry maximum 4 molecules of O_2.
- Binding of O_2 with haemoglobin is related to partial pressure of oxygen (PO_2)
- The factors which can interfere with these binding are PCO_2, hydrogen ion concentration. $[H]^+$ and temperature
- Association of oxyhaemoglobin takes place in the alveoli where the partial pressure of O_2 is high, partial pressure of CO_2 is low, so less hydrogen ion concentration and low temperature
- Dissociation of oxyhaemoglobin takes place in tissue where partial oxygen in low, partial partial pressure of CO_2 is high, so high $[H]^+$ and high temperature
- Increase in ~~the~~ PCO_2 & H^+ ions concentration at tissue capillary will trigger the oxyhaemoglobin to release oxygen this is called Bohr's ~~Effect~~ Effect.
- A sigmoid curve is obtained when the percentage saturation of haemoglobin with O_2 is plotted against PO_2. This curve is called oxygen dissociation curve

NEET. - P50 value is a indicator for affinity for haemoglobin with O_2. It is value where the PO_2 at which 50% of haemoglobin gets saturated.

- P50 value of human beings is 25 mm Hg



- when PO_2 is zero % saturation of haemoglobin with O_2 is zero. ooh
- when PO_2 is 25 % saturation of haemoglobin with O_2 is 50 ie, 50% of haemoglobin is saturated.
- when PO_2 is 40% saturation of haemoglobin with O_2 is 75
- when PO_2 is 95% saturation of haemoglobin with O_2 is 97-100.
- Every 100ml of blood delivers 5ml of O_2. when graph shifts towards the left then the PO_2 is high. The graph shifts towards right when PO_2 is low.

Transport of Carbon dioxide

- CO_2 is transported in 3 forms

i 7% of CO_2 is transported in a dissolved state through plasma as carbonic acid

ii 20-25% of CO_2 is transported by RBC as carbamino haemoglobin. This binding is related to PCO_2 is high and when PO_2 is low formation of carbamino haemoglobin takes place in tissue.

iii 70% of CO_2 is carried by RBC as bicarbonate. RBC contains high concentration of carbonic anhydrase where CO_2 along with H_2O forms carbonic acid and later dissociates into bicarbonate and H^+ ions

diffuse into plasma and chloride from plasma will diffuse into RBC to maintain ionic balance

- Chloride effect are the process that occurs in the cardiovascular system when chloride ions moves into RBC's from the plasma.

$$CO_2 + H_2O \xrightleftharpoons[\text{anhydrase}]{\text{carbonic}} H_2CO_3 \text{ (carbonic acid)} \xrightleftharpoons[\text{anhydrase}]{\text{carbonic}} HCO_3^- + H^+$$

HCO_3^- → plasma, H^+ → Cl^-

- At the alveolar side PCO_2 is low, the reaction proceeds in opposite direction leading to the formation of CO_2 & H_2O
- At the alveolar level the CO_2 which is formed is released out.
- Every oxygenated blood delivers 4ml of CO_2

Regulation of Respiration

- Human beings have ability to maintain and moderate the respiratory rythym to fulfill the demand of the body tissue this is done by nervous and chemical system.
- There are 2 respiratory centre :-

i Respiratory rythym present in medulla oblongata which is primary responsible for this respiration. This centre maintains the rythym, inspiration ie, 0.2s, Expiration - 0.3s ie, pneumotaxic centre.

- Pneumotaxic centre present in the pons region which reduce the duration of inspiration and after the respiratory rate :
- Haema
- chemosensitive present to the respiratory rythm centre which is highly sensitive to CO_2 and H^+ ions increase in the substrate can activate the centre is which in turn can make necessary adjustment in the respiratory process by which substance can be regulated.
- Receptors associated with aortic arc and carotid artery also can recognise changes in CO_2 & H^+ ion concentration and send necessary sig to the rythm centre for remidial actions.
- Roll of O_2 in regulation of respiratory rythm is quiet insignificant

Note:-

1 7% CO_2

$CO_2 + H_2O \rightleftharpoons H_2CO_3$
carbonic acid

2 20-25% CO_2

$CO_2 + HbNH_2 \rightleftharpoons Hb-NH-COOH$
carbaminohaemoglobin

3 $CO_2 + H_2O \underset{\text{carbonic anhydrase}}{\rightleftharpoons} H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$